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ABSTRACT

Digital libraries are moving from research and development into commercial use. If they are to realize their full potential, however, the experiences of end users need to be taken into account from the earliest stages of design. Those end users are typically individuals who have no particular skills in information retrieval, and are accessing library resources from their own desks, without support from a librarian. These factors clearly have implications for design. The aim of the work reported in this paper was to better understand the usability issues raised when digital libraries are used in a natural setting. The method used was a protocol analysis of users working on a task of their own choosing to retrieve documents from publicly available digital libraries. Various classes of usability difficulties were found. This paper focuses on "use in context"--that is, usability concerns that arise from the fact that libraries are accessed in particular ways, under technically and organizationally imposed constraints, and that use of any particular resource is discretionary. The concepts from an Interaction Framework, which provides support for reasoning about patterns of interaction between users and systems, are applied to understand interaction issues. (Contains 17 references.) (Author/AEF)

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Use of Multiple Digital Libraries: A Case Study

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Use of Multiple Digital Libraries: A Case Study

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ABSTRACT
The aim of the work reported here was to better understand the usability issues raised when digital libraries are used in a natural setting. The method used was a protocol analysis of users working on a task of their own choosing to retrieve documents from publicly available digital libraries. Various classes of usability difficulties were found. Here, we focus on *use in context* – that is, usability concerns that arise from the fact that libraries are accessed in particular ways, under technically and organisationally imposed constraints, and that use of any particular resource is discretionary. The concepts from an Interaction Framework, which provides support for reasoning about patterns of interaction between users and systems, are applied to understand interaction issues.

Keywords
Digital Libraries, video protocols, interaction modelling, HCI.

INTRODUCTION
Digital libraries are moving from research and development into commercial use. If they are to realise their full potential, however, the experiences of end users need to be taken into account from the earliest stages of design. Those end users are typically individuals who have no particular skills in information retrieval, and are accessing library resources from their own desks, without support from a librarian.

These factors clearly have implications for design. In particular, libraries need to be "walk up and use" systems that are easily learned; while more experienced users may require powerful features that support them in performing focused searches, novice users need to get early results for minimal effort [5]. The study reported here investigated how comparative novices work with existing digital libraries, focusing particularly on the patterns of interaction and difficulties they experienced. Many of these difficulties are not apparent when a library is tested in isolation. Whereas users of physical libraries have to move very deliberately from one library to another – often with a substantial time interval between the use of one and the use of the next – users of digital libraries can move almost seamlessly between them, sometimes without even noticing the transition. The focus of this study is on use of multiple digital libraries within a single session, and on user experiences of the interaction.

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BACKGROUND
We briefly review related work on use in context and on types of use. These other studies provide the academic context for the study presented here. We then present an overview of methods used in previous studies, relating the methods to the kinds of findings those studies could establish. In particular, an understanding of the alternatives was used to guide the design of the study reported here.

1.1 Use in context
Several studies have looked at digital libraries in context – that is, not just the library itself, but also how it sits within a larger frame of use. One example of such studies is Bishop's [3] consideration of the use of digital libraries by people from different social and economic backgrounds. Her studies indicate that people from different backgrounds (low-income and academic) can easily be put off using digital libraries – small problems tend to be magnified until they deter potential users, and lack of awareness of library coverage often prevents users from understanding what they could get out of the libraries. As libraries are becoming increasingly available for general use, the finding that people are easily deterred has to be taken seriously; our results, as presented below, highlight some of the deterrent factors, including poor reliability, inadequate feedback and the time taken to familiarise themselves with a new library.

Covi and Kling [7] investigated patterns of use of digital libraries by different groups of users, and how they vary across academic fields and universities. They focussed on interviewing potential users and, moreover, were concerned primarily with university members, rather than considering the population at large. Their study led them to conclude that the development of effective (useful and used) digital libraries needs to take account of the important roles played by other people within the broader system of use (notably colleagues and librarians), and that the views of end users, as well as those of librarians and computer specialists, need to be understood for effective design. Whereas Covi and Kling were concerned with how library use fitted in with overall working patterns, the study reported here is looking at how a particular interaction between a user and digital libraries evolves – i.e. the patterns of interaction, rather than the patterns of use. As shown below, the decisions taken by computer scientists and

librarians have substantial impact on the user experience, in ways that are hard to anticipate.

1.2 Types of work with digital libraries

One approach to understanding users' views is to analyse the kinds of work people perform with library resources. In this section we summarise studies of the kinds of things people get up to, or might get up to, in a digital library.

Searching for interesting articles is often the first thing that comes to mind when considering "digital libraries". However, as is being increasingly recognised, searching is not just a case of entering a search term and viewing a list of results. Furnas and Rauch [9] found that in searching for information a "one-shot query" is very rare. More typical is an extended and iterative search which involves opportunism; that is, the searching evolves over a period of time and relies on users being able to follow new (interesting) paths as they appear, which may not necessarily have been specified at the start of their search.

These notions of extended searching are supported by research carried out in conventional libraries [14]. As with digital library studies, O'Day & Jeffries found that one-shot searches were rare. Rather, they found that single searches evolved into other kinds of searching which they identified as: monitoring a topic over time; following an "information-gathering plan"; and exploring a topic in an undirected way. The findings of the current study are consistent with those of others, but illustrate that many searches are unsuccessful.

People do not just search for items in digital libraries, but also browse for them. Jones *et al.* [12] characterise this distinction as follows:

1. **Browsing** – users traverse information structures to identify required information
2. **Searching** – users specify terms of interest, and information matching those terms is returned by an indexing and retrieval system. Users may, in turn, browse these results in an iterative manner as discussed above.

Gutwin *et al.* [11] discuss the browsing in digital libraries, but tend to focus on how user interfaces they develop can support browsing, rather than considering what browsing is. However, in their discussion of browsing support they do categorise the purpose of browsing as follows:

1. **Collection evaluation:** What's in this collection? Is it relevant to my objectives?
2. **Subject exploration:** How well does this collection cover area X?
3. **Query exploration:** What kind of queries will succeed in area X? How can I access this collection?

These can all be considered aspects of familiarisation: with the type of information in collections and how the library works. In the study reported here, many of the purposes associated by Gutwin *et al.* with browsing arise in situations where there is no significant "browsing" activity – i.e. no substantial traversal of information structures. The purposes of an interaction and the types of behaviour (e.g. searching vs. browsing) do not appear to be closely linked. Nevertheless, the identification of these purposes is helpful: in the discussion below, these kinds of purposes are discussed under the heading of "familiarisation".

Once a document has been located a user typically does some work with it (not necessarily immediately afterwards) – otherwise, there would be no point in finding it in the first place. Amongst the activities associated with working with documents are reading and annotating them. One important finding about reading activity [1, 2, 13] is that people do not simply read articles from beginning to end, but rather move between levels of information – for example, from authors and titles to reading the conclusion. Current digital libraries available via the web are, for various reasons, limited in terms of the kinds of reading they support. Even with such technical restrictions, there were substantial variations between subjects in this study as regards the reading processes they adopted.

As well as reading, people also create, update, and annotate documents. O'Hara *et al.* [15] focussed on such writing activities in their studies of PhD students' use of libraries. They found that reading and writing were inextricably intertwined. Existing web-based library interfaces do not support any writing activities, so subjects in this study saved and printed relevant articles, for future organisation and annotation.

1.3 Techniques Used in Studies

Many different techniques have been used to study people's use of digital libraries. This section outlines the range of techniques used and their applicability. An understanding of these past studies and their scope was used to design the study described here.

Adler *et al.* [1] and O'Hara *et al.* [15] asked people to keep **daily notes** of their document activities, and followed up these descriptions with structured interviews. Such a technique has the advantage of low effort on the part of the analysts. However, a large load is placed on the participants as they have to keep notes of their activities. Moreover, as individuals keep their own diaries there will be differences between their note taking styles which may be significant and cause problems in generalising results. However, such an approach helps us to understand what people do and why they do it, which can give useful input to design or some qualitative evaluation results.

Questionnaires, on-line form filling, or registration documents can provide simple feedback. Bishop [3] used registration documents to build up an understanding of the different backgrounds of digital library users. In contrast she used surveys to find out information about users' use of the system after a period of time. Advantages of using such techniques include the ability to get a large response, but the information returned is often shallow – typically just simple answers to questions asked with no explanations of answer rationale. Theng *et al.*'s work [17] contrasts these approaches by using extensive questionnaires with a small group of users after they have completed tasks with digital libraries. These questionnaires elicit users' perceptions of the digital libraries used but, again, they provide no means of assessing why users felt as they did.

Several studies, e.g. [2, 3, 13], have employed **transaction logs** to gain an understanding of the activities users were engaging in with digital libraries. These logs give quantitative accounts of user actions and so can be used to make statements such as "(about 5%) took advantage of the ability to search for terms in individual components of articles" [2]. However, such logs do not provide an understanding of why users use particular features of systems. Understanding why things have happened is typically tackled by interview and possibly diary studies.

Several studies have investigated how people use particular interfaces and how their use differs between interfaces and between tasks. For example, Bishop [3] and Park [16] used **experimental design** to compare the applicability of user interfaces for digital libraries. The use of experimental design gives statistically significant results, but such studies are costly to develop and run, and can only answer specific questions. In these cases, the aim was broadly to inform design and redesign of a particular interface. Therefore, the user and a single interface could be considered as a "closed" system, independent of external influences. This contrasts with the present study, for which use in context is the primary concern.

Bishop [2] used three **focus groups** to elicit understandings of how faculty members used journal articles, and what requirements such use placed on design of digital libraries. Following on from that, Bishop [3] used focus groups to help understand different socio-economic backgrounds of digital library users. Although focus groups are useful for gaining an overview of the issues and problems, they tend to produce information which is often sketchy and in outline form.

Bishop [2, 3] used **interviews** to follow up on topics that were raised in her focus groups. This approach allows the analysts to develop a fuller understanding of the issues raised in the focus group, but interviews are time consuming and are, again, producing qualitative results which feed into design. Other studies such as those conducted by Covi and Kling [7] relied solely on interviews to assess people's perceptions and use of digital libraries. Approaches such as those employed by Furnas and Rauch [9] involved a combination of techniques as they used interviews to inform further observation of people using digital libraries. In contrast Marshall *et al.* [13] used interviews to follow up other techniques such as examination of transaction logs; their interviews allowed analysts to probe why users were performing certain patterns of interaction identified from the logs.

Observing what people do as they use systems is a time consuming activity. However, it can provide useful insights into the usability of systems. Bishop [3] discusses her use of observation to gather information on engineering work and learning activities. This information can then be used to inform (re)design, and/ or followed up in other ways such as interviews, as illustrated by Furnas and Rauch [9].

From the view of the studies presented here it is clear that although there has been work on studying the usability of specific user interfaces for searching, and to a lesser extent browsing, in digital libraries there has been little work on understanding the nature of these tasks or how libraries are used in a natural setting.

METHOD

The study reported here aimed to achieve a better understanding of how users interact with digital libraries within a single session, but not necessarily using a single library.

Because we wished to gather detailed interaction data, techniques such as diary-keeping, interviews, transaction logs and focus groups were inappropriate. A video-based observational study with think-aloud commentary was selected as the most appropriate means of gathering data, with a short debriefing interview a few days later to clarify any issues raised by the video data.

Five users were recruited for the study. Three of these were first year PhD students (referred to below as "A", "B" and "C"), one a final-year PhD student ("D") and one an experienced academic ("E"), all computer scientists. A – D were recruited as subjects specifically for this study; E, aware that this study was being conducted, offered to participate while performing a self-defined library searching task.

The aim was not to give users artificial tasks, which are liable to be either too precisely defined to be natural or too meaningless for participants, but to ask participants to select their own tasks to work on. Therefore the task defined for participants A – D was simply to obtain at least one paper on their own research topic to help with their literature review, using their choice of libraries from a given set (easily accessed via bookmarks in a web browser). They were asked to think aloud while working. They were provided with a little information about each library, as shown in Table 1. Access rights for each library were defined by the subscription held by the organisation in which they are based. Note, in particular, the restriction on ACM access – a cause of difficulties as discussed below.

Table 1: bookmarked libraries for users A – D.

ACM Digital library www.acm.org/dl/	Full text access only to journals and magazines (not conference proceedings)
IDEAL www.idealibrary.com	Access only to articles prior to 1998
NZDL www.nzdl.org	Full text articles
EBSCO www-uk.ebsco.com	Full text articles
Emerald www.emerald-library.com	Full text articles
Ingenta www.ingenta.com	Full text articles

As noted above, E was not recruited in the same way, but offered to participate. She was planning to search for articles on particular topics to help with writing academic papers, and volunteered to do this with a video camera running, and to "think aloud" while working on her self-defined task. Consequently, she used digital libraries of her own choosing, and did not have explicit information about limitations on access. She held a personal subscription to ACM, so she was not subject to the same restrictions as other users.

Users A, B, C, D and E worked with the digital libraries for 57, 62, 62, 51 and 80 minutes respectively. The video data was then transcribed, including speech and some description of interaction between user and computer system. It was analysed using the Interaction Framework [4]. Extracts from these transcripts are used in the following sections as source materials for examples.

1.4 Interaction Framework: overview

The Interaction Framework is an approach to describing actual or possible interactions between agents (users and computer systems) in terms of the communicative events that take place between those agents, and the patterns of interaction. Using this neutral language, which aims to take neither a user- nor a

computer-centred view of the interactive system, we can identify and discuss properties of the interaction that might or might not be desirable. For example:

- **Blind alleys** are interactions such that the objective is unachievable, but where that fact does not become apparent until some way into the interaction.
- **Discriminable events** are ones that another agent can easily choose between.
- A **canonical interaction** is one that achieves all its objectives as efficiently as is theoretically possible. In the case of digital libraries, such objectives will include accessing particular papers, accessing papers on a particular topic or general subject area, and gaining **familiarisation** with a collection content, type or features.

Central to any successful interaction is the idea that users must have an adequate understanding of the state of the system. Put in neutral terms, the user and system must share "common ground" [6] – that is, each interactional event has to communicate sufficient information to enable the agents to maintain common ground.

SUMMARIES OF INTERACTIONS

Before presenting detailed results, summarising the important difficulties found, we present a brief overview of the interaction of each participant with the available digital libraries.

1.5 User A

User A was interested in papers on electronic commerce. As she started working, she spent a while browsing unrelated material, as if orienting herself to browsing, before selecting a link from the bookmark list. She selected the ACM digital library, and spent some time reading through the introductory page. She then searched for "the best of electronic commerce", but seemed rather confused by the results returned. She selected an alternative search mechanism and repeated the search. She found various articles that were "interesting" but did not print them. Although she limited her search in ACM to "journals only", conference articles were listed among the search results; when she tried to download one of these articles, she was asked to enter a user name and password, which she did not have, resulting in an authorisation failure.

She moved to the Computer Science Technical Reports link in NZDL, and got over a thousand hits on her search. She reformulated her search several times, and still too many items were returned. Eventually, she found an article she wished to view and download, but failed to download it, for reasons discussed in section 5.1 below. She then moved on to EBSCO. When her search results were returned, she commented that "this is more readable than from other libraries". She successfully found, saved and printed one article.

1.6 User B

User B was looking for material on knowledge management, text mining and link analysis. Although he has used other browsers, he did not have previous experience of using Netscape, so he starting by browsing Netscape pages before connecting to the ACM digital library via the bookmarks. Before specifying the search terms, he spent some time "trying to understand how to make the search". When searching the ACM library, he did not restrict his search to journals only, and consequently received many hits that were conference proceedings; like user A, he got authorisation failure when he tried to print any of these.

Although new to Netscape, user B was a relatively sophisticated user of information retrieval systems. For example, he understood how to use quotation marks selectively in search queries and also resorted quickly to using two browser windows so that he could continue working in one window while a document was downloading in the other. Using this strategy, he explored the EBSCO library, then NZDL, then Ingenta – continually flicking from one window to the other as pages were loading. One apparent consequence of this is that his behaviour was more reactive than that of the other users: he appeared not to form clear beliefs about the state of the system, but to simply respond to whatever was currently displayed, and the interaction appeared relatively unstructured and haphazard.

1.7 User C

User C was searching for material on Growing Cell Structures (GCS), text classification and Self Organising Maps (SOM). He started by accessing Emerald, but rapidly switched to Ingenta, when his first few query formulations returned no results. Results from Ingenta were more promising; in fact, there were so many hits he appeared to be overwhelmed: "I found over three hundred documents here". Several times, he selected an article with a promising title and followed the link "full text at Science Direct", but was then refused access. [The user organisation had a subscription to Ingenta journals but not to Science Direct.] He saved several abstracts and printed one full text article from Ingenta. He accessed the IDEAL and ACM libraries twice each, but each time judged them "too slow". In EBSCO, he failed to find any matches to his search terms. He returned to the Emerald library, and reformulated his query: "I think I made some mistakes last time. I searched for GCS as the keyword so this time I searched for GCS for full text and I found something". Later on, his search took him to a link "order the book", which took him from the library to an internet bookseller. He conducted further searches, using Emerald, Ingenta and NZDL, usually receiving either no matches or too many to deal with. In NZDL, he found an interesting article, but failed to download it. Although he could read the article on screen, he tried three times to download it, without success. By the end of his interaction, he had found some relevant material on text classification, but none on GCS or SOM.

1.8 User D

User D looked for different things in different libraries. He started with ACM, searching for articles on usability evaluation; a large number of results were returned. He tried to save a selected article to a "binder", but received "authorisation failure". He moved on to use NZDL, now searching for articles on "musical timbre"; although he found one that he skim-read on screen, he moved on quickly to search for "timbre perception", which returned results that he judged "more or less similar to my previous query". He opened second and third windows to access EBSCO and Emerald, but never switched between windows (they seemed just to be a historical record of where he had got to in a particular library). He browsed and submitted search queries in a relatively unstructured way, apparently trying to familiarise himself with the content and structure of the library. When he tried to

follow links to particular journals, an error message, "Type mismatch" was displayed. Subsequent tests indicate that this was a temporary error, but it had a strong influence on this particular interaction.

He tried to access Ingenta, but received an error message: Ingenta was unavailable. He moved on to Emerald, about which he commented: "It's actually good to have some basic description of the journals. It's not my area." After a quick look, he returned to ACM to search for articles on visual texture; on selecting a "Find related articles" link, he found something quite different that interested him – a case of serendipity in the search. He viewed the abstract and tried to download the paper, but got an "authorisation failure" – he "wasn't paying attention" when earlier told that he could download journal papers but not conference proceedings. He went on to successfully identify and download a relevant journal article.

1.9 User E

User E required information on diary systems, cognitive modelling and usability of Artificial Intelligence systems. In meeting these objectives she used three libraries: ACM, IDEAL and the New Zealand Digital Library (NZDL). These were used in a relatively orderly sequence of ACM, followed by IDEAL, and finally the NZDL. The search objectives were repeated to some extent with each information source as opposed to meeting each objective in sequence.

In detail, she spent most of her time using the ACM DL. Any articles she found that seemed relevant were printed for further review. Her first few searches were unsuccessful, yielding "no matches". A search for information on diaries and calendars was more fruitful. She then switched to browsing various collections, with mixed success. When she found an article that appeared interesting, she always printed it out, rather than trying to read it on screen. Overall, this user's interaction was the most fruitful, and by the end she had printed about a dozen articles.

RESULTS

Clearly, each of the five users in this study behaved in quite different ways when navigating the libraries, and the sample size is far too small to make any general claims about usage patterns or typical behaviours; this was not the purpose of the study. Similarly, the purpose has not been to conduct usability evaluations of particular libraries, or to pit them against each other. Rather, the aim has been to identify core usability issues that arise through the details of user interaction with digital libraries, where the users are not assumed to be interaction retrieval experts, and where use of any particular library is discretionary.

We discuss the main usability issues raised within this study under two headings: deterrent factors (and encouraging ones) that may influence future acceptance of digital libraries; and usability issues that arise as a direct consequence of libraries not being "closed" – i.e. that the interface between a library and other resources is easily traversed.

1.10 Deterrent factors for use in context

The users in this study all experienced substantial difficulties with using one or more of the libraries they accessed. Many of these difficulties resulted in blind alley interactions – that is, interactions that did not achieve the user's objectives. Some of these blind alley interactions took place over several minutes. For example, user A spent over six minutes trying to download an article from one library before giving up, commenting that "I've tried all, but I can't download". Some of her sources of difficulty are illustrated in Figure 1, where the warning message reads: "Expanding the text here will generate a large amount of data for your browser to display".

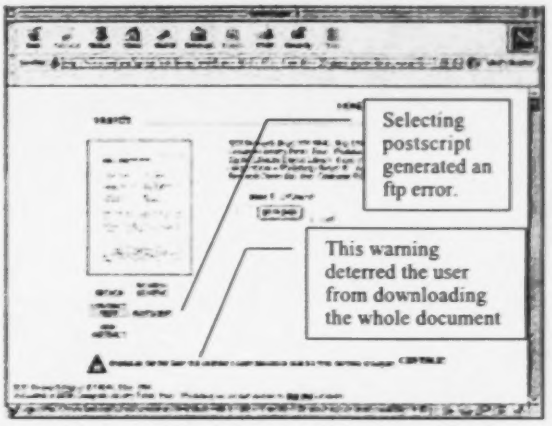

Figure 1: difficulties with downloading in NZDL

Most users suffered from a "triumph of hope over experience", repeating the same unsuccessful action several times without modification, and each time receiving the same result. For example, user B tried eight times to download full text of an article from Science Direct, while user C did the same six times. User C also tried to download the same postscript file three times, each time receiving the error message "Netscape is unable to find the file or directory named /pub/techreports/1993/tr-93-025psZ. Click the file name and try again". Similarly, user D tried three times to access the Ingenta library, each time receiving the error message "TfeLogin: Data decoding / encoding error". It is too early to follow up these users to find out whether or not their experience working with these libraries on this occasion has deterred them from any future use, but the productivity of all participants in the study was low (one document successfully retrieved after an hour of use for all except user E). Even the most successful user, E, commented at the end of the interaction that:

...I don't think I could cope with doing anything more. I don't feel that I've really found much, apart from on calendars, which I could focus. I haven't found very much that was actually very helpful.

The downloading difficulty of user A can be understood in terms of poor "common ground" between user and system – that is: the user did not fully understand the state of the system, or the meaning of the warning message, and consequently could not find a way around her difficulty.

The errors experienced by users C and D can be understood in similar terms: that the event communicating the fault to the user is insufficiently expressive for the user to comprehend and respond appropriately (see Figure 2). Accepting that occasional errors such as network faults are unavoidable, the challenge to the digital library designer is to communicate the status of the system (which may include multiple servers) effectively to the user.

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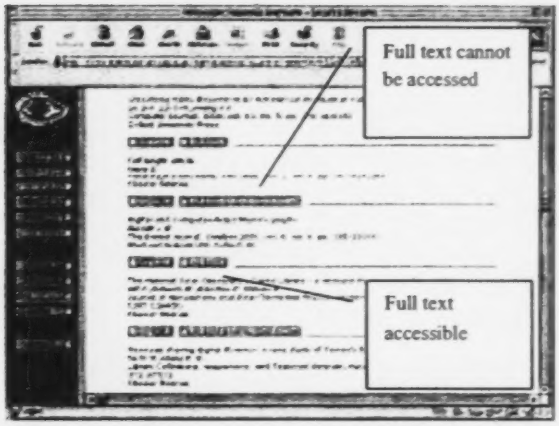

Figure 2: users did not understand the difference between the two sources of full text

Gould [10] discusses the importance of reliability when considering usability: a computer system that cannot be relied on to work predictably well is difficult to learn and use. Digital libraries accessed using standard web technologies are complex systems that are vulnerable to many kinds of failure. Some of the failures affecting basic accessibility of the library resources have already been discussed. Others have a more subtle effect on the interaction. For example, user A, aware that she could only access full text of journal papers (not conference proceedings) from ACM, conducted a search restricted to journals only. The following transcript shows the user's words, her [>actions] and the [<system feedback]:

> … so I will search in "all journals and proceedings"…no, "journals only"…
> [> selects "journals only"]
> [> clicks on "search" button]
> [< ACM DL – search result page]
> …I found 23 results… money in electronic… not that interesting. Electronic markets and intelligent systems…. This is interesting …
> […]
> … Building bridges with practice… I will have a look at this
> [> clicks on the document link]
> [< article abstract page appears]
> … this is very close to what I am interested in
> [> scrolls down the page]
> [< bottom of abstract article page displayed]
> [> clicks on the "full text" button]
> [< the pop-up window "User name and password" appears]
> Ow yaa. You have to get a username and the password because I haven't registered

Her confusion lasted some time longer. What appears to have happened here is that there was a temporary bug in the ACM library, or in the means by which the user's search specification was transmitted to the search engine, such that the search was not restricted as specified. Consequently, many of the results returned were articles from conference proceedings, but the user did not check this, believing that she had restricted her search to eliminate such results. A few days later, when we tried to reproduce the interaction as recorded on videotape, the problem had been corrected. Accepting that such errors are not always avoidable, it should be possible, as discussed above, to give more focused feedback, so that the user can understand and respond to the error in an informed way. In this particular case, the user was restricting her search because she was aware that she had authorisation (based on her host organisation's subscription) to access full text of journal articles, but not conference papers. Arguably, the system also has access to this information, and might have been designed so that the user's access rights were clearly indicated before she tried to download an article.

As well as failures, the user's choice of libraries is clearly affected by the quality of their experience with a library, and also their sense of familiarity with that library. Within the study reported here, the three dominant factors that determined perceived quality were: a sense of making progress (whether in finding relevant articles or in understanding a library better); a sense of the task being manageable (in particular, not an overwhelming number of alternatives with poor discriminability); and system response time being acceptable. We consider each of these aspects in turn.

1.10.1 A sense of progress

All participants had the experience of issuing search requests that returned no matches. Particularly for user C, this became very frustrating. E.g.:

> …I searched this author in several digital libraries and always cannot get anything ... this professor has published several papers in computer journals.

And:

> This haven't found anything about "GCS" too.

Where users have a sense that they are learning from their null results, they still seem to have some sense of progress. E.g. user A felt able to modify her search:

> [> clicks on the "search" button]
> [< "search result" page appears]
> …no matches… I haven't found any matches…Perhaps I shouldn't put trans… publications.,
> [> clicks on the browser "back" button]
> [< ACM DL – search page]
> … so I will search in "all journals and proceedings"…no, "journals only"…

Similarly, user E modified her search, but was still unsuccessful:

> [< search results page replaces search formulation page]
> No matches. Great.
> [> clicks back]
> [< search page replaces search results page]
> So even on full text. Of course, its possible, no.
> What happens if I turn off the human and try again?
> [> removes human from subject search terms]
> [< subject search is now "artificial intelligence" (note – author search is still "Hollnagel")]
> I would expect to get a fair amount.
> [> clicks search]
> [< search results replace search formulation page]
> No matches. Ha ha ha.

In this case, the source of the problem was that this search was conducted some time after an earlier one that has specified a particular author, but the user had not noticed that there was an

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author entry in the search specification. From the user's perspective this was a new context, a new query; from the system's perspective, this was an elaborate query (with no matches). Improved feedback – helping the user to understand exactly what the search results referred to – might well ease such situations and improve the user's familiarity with the system.

Conversely, users appeared to have a particularly strong sense of making progress when serendipity worked for them – that is, when they came across an interesting item that was unexpected in the current context. This happened twice to user E; e.g.:

> [- ACM DL list of papers in most recent DIS conference]
> Triangulation.
> That actually looks quite interesting.
> [> clicks on paper's link]
> [...]
> So I'll have a look at that one.
> [> clicks acrobat print button]

It also happened to user D:

> I'm looking into a visual texture related papers but I actually found something that doesn't seem to be related to that at all. It's about comparing two different methods of evaluations: empirical testing and walkthrough methods which is also interesting to me so... I'll just jump to that from the search .

While serendipity is difficult to design for (by definition), it can be supported through discriminability: it is important that it is obvious to a user when such items come into view – that the descriptions of items make their nature clear.

1.10.2 A sense of the task being manageable

While no matches is clearly not a desirable result, there has been little discussion of the effects of too many results. Within the Information Retrieval community, one focus of research, and one criterion by which the quality of a search engine is assessed, is the quality of search results returned, as measured against suitable metrics. In practice, the users in our study appeared to place more store by quantity, or at least discriminability, than quality. For example we have the following comments from users in response to various search results:

User A (having specified "some" of the search terms to be used in a search for "electronic commerce"):

> Here I found one thousand seven hundred twenty two commerce and two thousand...
> ...OK, I will have to go back and say all
> [> clicks on "back" button]

User C commented:

> Sometimes the search finds too many articles so it is a little bit boring to read all these article titles.

More encouragingly, user E was pleased when fewer results were returned:

> 16 documents, that not too bad.

As was user B:

> ...only seven, that's fine...

Repeatedly, users commented positively when the number of results was small (less than twenty) and negatively when it was large (typically over two hundred). We can understand this in terms of the discriminability of events and the number of alternatives: with a large number of results, it is generally not possible to discriminate between those possible future interactions that are likely to be successful and those that are blind alleys (relative to the user's objectives).

1.10.3 Response time: the pace of the interaction

Due to factors such as network bandwidth limitations, the geographical locations of servers, network loading, etc., the response times of libraries were very variable in this study. Dix [8] discusses the importance of the *pace* of the interaction being appropriate to the task properties. Two of the users in this study (B and E) responded to the pace being too slow by opening a second browser window and interleaving interaction with the two windows. (D also opened multiple windows, but only used them sequentially.) Both B and E commented on download time. For example, user E noted that

> We're going to work much more efficiently if we have a new navigator window...
> [> clicks browser file -> new navigator window]
> [< New window (2nd window) appears with home page]
> ... and have that one running in the background.

As switching between windows, B commented that

> ...it's taking quite a long time to download [...] ...so I can continue working with ACM...

C also reacted to the response time of certain servers, but responded in a different way – by avoiding those libraries completely:

> [> clicks on IDEAL link]
> It seems to be very slow. So I will stop and try another.
> [> clicks on browser "Stop" button]
> [> selects browser "bookmarks" folder]
> [< list of links displayed]
> [> selects ACM DL from the bookmarks]

While the cognitive demands of multitasking in this environment are not excessive (because neither task is time-critical), the similarity of the two tasks is liable to cause interference. Both B and E appeared to lose track of the state of the second window at times.

1.10.4 Familiarity

As noted above, user E made her own selection of libraries; for the other four users, information was intentionally re-ordered, both on the bookmarks list and on the accompanying paper documentation, so that users who followed the list order of libraries would naturally start with different libraries. Nevertheless, four of the five users started by working with the ACM library. Two (D and E) stated explicitly that this was because they were familiar with that library. For example, D commented:

> ...I've used this library in the past so more or less I know that I can find relevant papers ...what I'm looking for.

B commented about a library that he had not used before:

> ...let's try this one: EBSCO on line. I don't know it but it's always good to know new things.
> [...]
> ...what shall I do. ... I am trying to find out how should I operate this... favorite journals, let's try it.
> [> clicks on "Favorite journals" link]

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[<" Manage Favorites" pop-up window appears on the top of "EBSCO page"]

...I am trying to understand ...how to operate this...

These two examples illustrate familiarity (or lack of it) with different aspects of library use. D is concerned with the type of content (and his expectation of being able to locate relevant papers), while B is concerned with how to work with the library system and the navigation features it offers.

Other aspects include familiarity with content of collections or articles – type (e.g. the kinds of papers that are published in a particular journal), structure and detailed content. For each aspect of familiarity, the design challenge is to support recognition (e.g. E, reading the title of a paper: "I happen to know what that work is") and incremental learning. For example, user E had difficulty understanding the "binders" feature in the ACM library:

[- ACM DL search results page]

I don't know what happens when I tick them.

[...]

I've clicked these things now and I haven't got a clue what I'm meant to do with them. Hmm. I don't know what a binder is...

[> clicks and holds on binder link]

[< browser pops up menu of possible actions]

... help...

[> releases mouse]

[< page is replaced with page containing list of articles selected]

... please choose a binder from your bookshelf.

I don't have a binder, and I don't have a bookshelf as far as I'm aware.

One of the substantive challenges in designing usable, useful digital library systems is enabling users to learn features incrementally, so that they are not overwhelmed at the outset by a large number of alternative actions that are indiscriminable (because the user has no way of predicting the effects of any actions). This would include distinguishing between core and discretionary features (e.g. document management features can be learned after document retrieval features), and presenting information *in context* – at the time it is needed – as well as making novel features self-explanatory as far as possible.

1.11 Using multiple libraries

The main purpose of this study has been to focus on use in context. Many aspects of context have been discussed above while considering use of individual libraries and deterrent factors. In this section we consider additional difficulties that arise because libraries are accessed by users from a particular organisation, using particular technologies that interact in ways that may not have been anticipated.

Users were all working within a University setting, using a PC running the Netscape browser to access library resources. The setting and the task were designed to be as natural as possible. Two main classes of difficulty emerged in the sessions: understanding the access rights they had based on organisational subscriptions and working across boundaries (between libraries, other software, other systems). We consider each of these aspects separately.

1.11.1 Access rights

As described above, user A had difficulty downloading papers from ACM because she believed she had limited her search to those items to which she had access rights, but others were listed in the search results. User B also tried to download conference papers, having ignored the details on the user instructions. Similarly, as described above, users had difficulty understanding the difference between papers that could be downloaded via Ingenta, and papers that could not be downloaded because they were only available via Science Direct. A further potential difficulty of the same kind resides in the IDEAL library, where users have access rights only to journals from one publisher, but not others. These distinctions are poorly understood by users and inadequately explained within the libraries. Also, in the current dynamic environment where new resources are coming on-stream rapidly and spending decisions (e.g. on subscriptions) need to be reviewed frequently, users have great difficulty keeping track of what resources are available to them. Particularly as users are often working in various locations, without easy access to the information about permissions settings, that information needs to be made easily accessible at the point of need. Of the five libraries used in this study, one (IDEAL) has recently added a feature to give any user individualised information on their access rights, which is clearly recognition of the difficulty and a first step towards addressing this particular problem, which is just one aspect of the broader challenge of enabling user and library system to establish common ground.

1.11.2 Working across boundaries

Within this study, there were many cases of users traversing boundaries – between collections such as Ingenta and Science Direct, as discussed above, or between NZDL and various ftp sites, as exemplified in user A's interaction:

[< CSTR – browse result page displayed]

[...]

[< top of the page displayed]

...let's try the first one

[> clicks on the first link]

[<ftp://actor.cs.vt.edu page appears]

... so I can't find easily what I am looking for.

Such transitions, which are often not well marked for the user, demand that the user switch to a new way of working, with different navigation and other features, in an environment that looks and behaves suddenly differently. While transitions may be necessary, even desirable in some circumstances, their implications for users need to be better understood.

Because libraries are commonly made available via the world wide web, there are many cases where users can accidentally leave the library, following links to other web based resources. User C experienced this when following a link from Emerald that referred to a book: further information about the book could only be accessed via internet book stores:

[> presses "Review" button]

[< "review article" page displayed]

[> scrolls down the page]

[< bottom page revealed]

[> scrolls up the page]

[< top page displayed]

I'm trying the book.

[> scrolls down the page]

[< bottom page displayed]

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[> clicks on "order the book"] [amazon]
[< "amazon" page displayed]

User A also accidentally left a library – twice – as she searched for library resources. The first time was almost immediately after she had followed the ACM link from the bookmarks provided:

...what's new. Maybe if this is on the top then it will be more convenient for me.
[> clicks on the "search acm" button]
[< ACM search page displayed]
...are not included. What is not included?
[> types "the best of electronic commerce" into search box]
...it's a key word? Yes.
[< "key word" pre- selected]
[> clicks on "search" button]
[< "Search Result" page appears]
I have 83 pages matching my query and I have here 1 to 12
The score here is showing what is most related to my search
Strategic analysis reports...social impact...
[> scrolls down the page]
[< more results appear on the page]
... I will have a look at the "strategic analysis reports"

Figure 3: identifying the exit routes from a library

She is unaware of the fact that she is not using the digital library, but searching the ACM web site. This is the behaviour of a novice user who has just entered the ACM digital library for the first time, but she has clearly failed to discriminate between "search ACM" and "search the Digital Library". This is partly an artifact of the study, since she entered the library directly from "outside" without passing through the ACM web site, but such situations are common, particularly with the increasing provision of digital library portals that provide links to various libraries from one web site.

Later in the interaction, she again left the library – rather more briefly – as she tried to return to the digital library home page:

[> ACM DL search page displayed]
[> click on "home" button]
[< ACM – home page]
So, I would like to find some journals, articles, magazines...
... So where can I find them...
[> clicks on "digital library" link]
[< ACM digital library page]

Figure 3 illustrates the source of these interactional detours: the user has failed to discriminate between the type of links on the top links bar (which are generic ACM links) and those on the body of the page, which are digital library links.

As well as boundaries with other web based resources, users also have to work across boundaries with other software and the operating system. For example, user C had some difficulty saving a file, shifting attention from library use to working with the operating system. User B accidentally closed his browser session, and had to start again:

[< further pages displayed]
...not interesting...
[> closes the Netscape window]
[< "word" document page displayed]
[> closes the Microsoft "word" application]
[< pop-up window "Microsoft Word" appears "Do you want to save changes in the document"]
[> clicks "no" button]
[< computer desktop appears]
...I got out of the "Netscape"
[> clicks on "Netscape" icon]
[< "Netscape" window opens]
...bookmarks...now again..

As the only user in this study who printed files, rather than saving them, user E also had to integrate library work with using other resources – notably a printer:

It's all tied up for the minute, so I'll go and collect some things from the printer.
[- ACM DL 1st window showing ontology paper]
OK. So I don't know how I will know if I've got everything I've printed out. Because I'm losing track of it completely. But I think that's been sent and not needed anymore.

Such boundaries cannot be easily eliminated, but the consequences of making transitions across boundaries can be minimised; for example, user B had difficulty restoring the state before he closed the browser, while user E had difficulty establishing exactly what state the system was in (including what had and had not been printed or fully downloaded): common ground needs to be restored.

CONCLUSIONS

We have considered deterrents to the use of digital libraries, and usability issues that are raised by the pragmatics of use in a natural setting – taking account of organisational and other concerns. One way of considering usability is as the absence of any undesirable features of the interaction; therefore, the focus in this paper has been mainly on difficulties experienced rather than successes, although all users achieved some success in their interactions. If some libraries have been discussed more than others, it is largely because those libraries were used more extensively – a consequence of use being discretionary.

In terms of the Interaction Framework concepts introduced earlier, the most important design issues have been found in this study to relate to:

1. **Familiarity**: users need to be able to rapidly acquire understanding of core library features, content and

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structures, if they are to gain a sense of progress while working with the library.

2. **Blind alleys**: many interaction sequences did not achieve the user's objectives. This is most obvious when a search returns "no matches", but occurs in some more extended interactions. Some interactions that have no material outcome achieve improved familiarisation (the user learns more about the library structure or contents), but others do not. Perhaps more surprisingly, some interactions that resulted in a large number of hits failed to achieve the user's objectives because the user was (apparently) overwhelmed by choice and retreated from the search results page, due to poor discriminability.
3. **Discriminability**: forming understandings of the content and possibilities in a collection relies on being able to discriminate between possibilities. Therefore we need to ensure that the potential events are easily discriminated.
4. **Serendipity** – finding unexpected interesting results – seems to give users a particular sense of making progress. Serendipity depends on users being easily able to identify interesting information, which is one aspect of discriminability.
5. **Working across boundaries**: transition events, where one agent (user or computer system) changes context, can often be a source of interactional difficulties; measures need to be taken to ensure agents maintain common ground and understand the consequences of transitions.

This study has identified many cases where decisions taken by computer scientists and librarians have had unanticipated consequences. The incremental approach to delivering library resources has many positive advantages (e.g. ease of introducing new features) but can also result in inconsistency as users move between libraries, particularly where that move is made so smooth that users are often unaware it has even happened. The use of site licenses that permit partial access to resources, or access that is temporary, makes systems unpredictable to users, so that they cannot develop an adequate (usable) understanding of what detailed goals are and are not achievable. If theoretical possibilities are to become practical solutions, then the kinds of pragmatic issues raised by this study need to be taken into account in the design of future libraries.

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